Precise in situ zircon U/Pb dating by LA-SF-ICP-MS: comparison of two different laser systems

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In situ U/Pb dating of zircon minerals by LA-ICP-MS is a well-known method to determine the formation age of basement rocks or sedimentary deposits. With this study, we optimized two different LA-ICP-MS setups in order to evaluate the precision and accuracy of the $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratios, upon which the U/Pb dating method is based. In the first setup, a GeoLas M laser from MicroLas (Germany) was coupled with an Element XR SF-ICP-MS from Thermo Scientific (Bremen, Germany). In the second setup, we used a UP193HE laser from New Wave Research Inc. (Fremont, CA, USA), coupled to the same mass spectrometer. Both laser systems are ArF excimer-based, providing a laser beam with a deep-UV wavelength of 193 nm. For the GeoLas ablation system, a ~30 cm³ ablation cell was mounted on a software-controlled translation stage. In comparison, we used a custom designed (Frei and Gerdes, 2009) teardrop-shaped ablation cell with a significantly lower volume of ~2.5 cm^3 for the UP193HE system. This low-volume cell significantly decreases warm-up and washout times (by up to five times).
For each setup, we determined both the short-term and long-term precision and accuracy based on a sequence of several well-characterized zircon standards (91500; Plešovice; QGNG). The PepiAGE software was used to perform data-reduction (Dunkl et al. 2009). Laser-induced elemental fractionation and instrumental mass discrimination were corrected by normalization to the reference zircon GJ-1 (ID-TIMS $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratio of 0.9761 and 0.8093 respectively – Jackson et al., 2004). For the UP193HE setup, laser induced elemental fractionation was corrected based on the arithmetic mean of all measured Pb/U ratios. Correction based on the intercept method gave the same results. The high-volume ablation cell for the GeoLas system only gave good results when using the arithmeric mean. In all analyses except one, a second-order fit was used as best prediction of instrumental drift. Based on the corrected isotope ratios, concordia ages were calculated with Isoplot (Ludwig, 2003).
For the UP193HE system, the average measurement uncertainties (2σ) based on 47 analyses of the Plešovice zircon standard yielded 4.4% and 6.3% for the $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratios, respectively. The weighted mean concordia age of all analyses was 338 ± 2 Ma which is in excellent agreement with the reported ID-TIMS age of 337.1 ± 0.4 Ma. The Pb/U precision for the 91500 (4.5%, 6.9%) and QGNG (3.9%, 5.1%) zircon standards are similar to that of the Plešovice zircon standard. The GeoLas system yielded better precision for all standards (2.2%, 4.1% for the Plešovice zircon) but a lower accuracy (341 ± 3 Ma for the Plešovice zircon). In conclusion, the UP193HE laser gives the best advantages with a precision still good enough for geological applications. However, a low-volume cell mounted on the GeoLas laser (under construction) might result in a similar high sample throughput as the UP193HE system, but with an even better precision.

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